ANALYSIS OF STOMACH CONTENTS OF THE SMALLTAIL SHARK *CARCHARHINUS POROSUS* FROM NORTHERN BRAZIL

by

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ABSTRACT. - Feeding habits of the smalltail shark, *Carcharhinus porosus*, were investigated by analyzing stomach contents of 684 specimens caught between 1984 and 1987 in coastal waters off Maranhão state (Northern Brazil). Twenty five percent of the stomachs contained food, 80% of which (numerically) were fish. Main prey items consisted of croakers (Sciaenidae) *Macrodon ancylodon* and *Stellifer naso*. All fish species present in the stomach contents are abundant in shallow waters, suggesting that *C. porosus* is an opportunistic predator. The highest proportions of empty stomachs were observed from September to November in both juveniles and adults. The mean weight of full stomachs ranged from 40 to 60 g in adults, and from 20 to 25 g in juveniles. On average, both juveniles and adults had one prey item in their stomachs. Adults may prey upon Elasmobranchs, whereas juveniles showed a wider food spectrum. Ontogenic differences in diet were observed for both males and females. The evidence presented shows that size selection of prey is related to predator size.

RÉSUMÉ. - Analyse des contenus stomacaux de *Carcharhinus porosus* (Carcharhinidae) au nord du Brésil.

Le régime alimentaire du requin tiqueue, *Carcharhinus porosus*, a été étudié en analysant des contenus stomacaux de 684 spécimens capturés dans les eaux côtières de l'état du Maranhão (Nord du Brésil). Les estomacs de 25% des requins contenaient de la nourriture qui était constituée à 80% de poissons. Les principales proies sont des Sciaenidae, *Macrodon ancylodon* et *Stellifer naso*. Toutes les espèces de poissons identifiées dans les contenus stomacaux sont abondantes dans la région du Maranhão, suggérant que *C. porosus* est un prédateur opportuniste. Les taux les plus élevés d'estomacs vides ont été observés entre septembre et novembre, aussi bien chez les jeunes que chez les adultes. Le poids moyen des estomacs pleins variait de 40 à 60 g pour les adultes et de 20 à 25 g pour les jeunes. En moyenne, l'estomac d'un jeune ou d'un adulte contenait une proie. Les estomacs des mâles adultes étaient les seuls à montrer des Elasmobranches parmi les proies. La nourriture des jeunes est considérée comme plus éclectique que celle des adultes. Des variations du régime alimentaire ont été observées entre les différents stades ontogéniques chez les mâles et chez les femelles. Une relation entre la taille des proies et celle des prédateurs a pu être établie.

Key-words. - Carcharhinidae, *Carcharhinus porosus*, ASW, Equatorial Atlantic Coast, Shark diet, Stomach contents.

An overall maximum sustainable yield (YMS) of 36,000 tons/year has been estimated for several coastal shark species together in the area between 1°30'S / 45°10'W and 10°S / 35°W. Of such a yield, 23,000 tons/year was the estimated YMS only for the coast of Maranhão State alone (Anon., 1976, 1983). Despite such levels of abundance, biolo-

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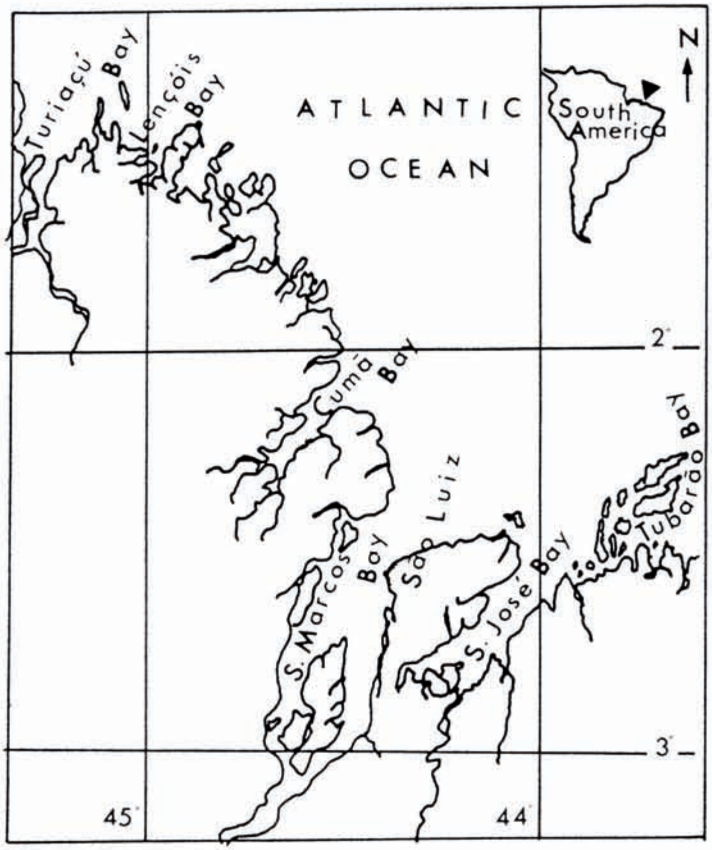

Fig. 1. - Collection sites of *Carcharhinus porosus* in Maranhão State, Northern Brazil.

gical characteristics and population parameters utilized for stock management are poorly known for elasmobranchs, both in this area and in general (Holden, 1974).

Studies conducted from 1984 to 1987 in this area showed that the smalltail shark, *Carcharhinus porosus,* is the most abundant elasmobranch species caught in drift gill net fisheries (Lessa, 1986). This small species occurs in shallow coastal waters from 30°30'N to 24°59'S (Compagno, 1984; Sadowsky, 1967). Despite its wide distribution along the coast of the western Atlantic, few studies have dealt with this species and data on its diet are still rudimentary. Compagno (1984) reported this species as being generally a piscivore, consuming sardines, sea catfish, croakers, jacks, grunts and other small sharks.

To supply data on the feeding habits of *C. porosus* the present study analyzed samples collected from 1985 to 1987 in northern Brazil. The purpose of this paper is: 1) to list the items which make up the feeding spectrum, 2) to quantitatively analyze the diet, 3) to compare juvenile and adult feeding habits, 4) to investigate the existence of prey selectivity as a function of predator size, as postulated by Saul and Lessa (1991), and 5) to compare the diets of males and females during their ontogenetic development.

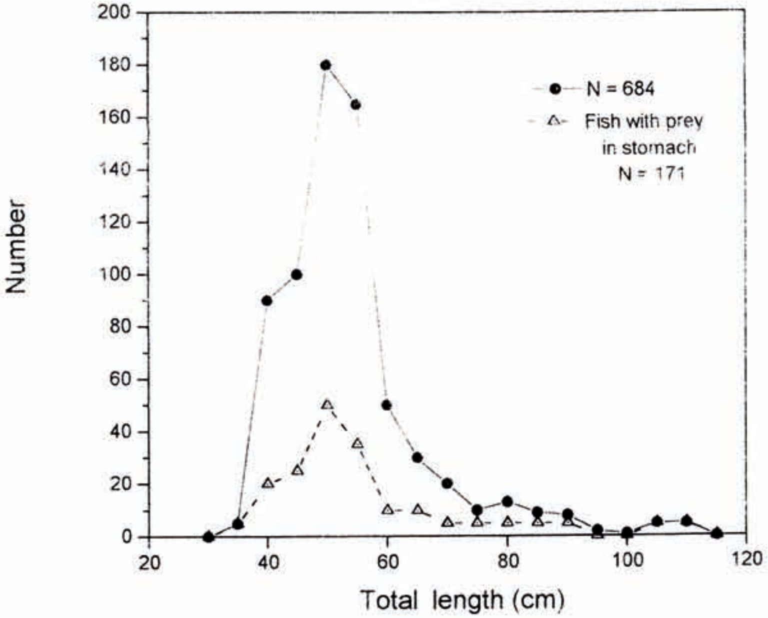

Fig. 2. - Length frequency distribution of *Carcharhinus porosus* collected from 1985 to 1987 off Northern Brazil.

MATERIALS AND METHODS

Samples were obtained during 45 collections in the area between Tubarão and Lençois Bays (1° 05' - 2°45'S / 43°30'W - 45° W) from 1985 to 1987 (Fig. 1). Drift nets, 900 m in length, 7.2 m in height, and of 8.0 cm stretched mesh size, targeting the Brazilian Spanish mackerel *Scomberomorus brasiliensis* were deployed from sailing boats operating in shallow waters (16 to 40 fathoms). Mean surface water temperature was 28°C. In this region the rainy season (Winter) is from December to May and the dry season (Summer) from June to November.

The total sample was made up of 684 specimens (Fig. 2), 362 males and 322 females. Male sizes ranged from 35 to 90 cm TL, and female sizes from 30 to 110 cm TL.

Total length (TL, cm), gutted body weight (g) and stomach weight (g) were recorded for each specimen. Dietary contents were analyzed to the lowest possible taxon or category, depending on the state of digestion of each item. When identification was impossible, prey items were placed in the "others" category. Fish presenting everted stomachs were discarded.

Teleosts present in stomach contents were identified according to Figueiredo (1977), and Figueiredo and Menezes (1978, 1980), and compared to a reference collection. Fish in an advanced state of digestion were identified to species level using otoliths which were compared to an otolith reference collection. The total lengths of teleosts present in stomach contents were estimated using previously established relationships between otolith size and the size of individuals (Saul and Lessa, 1991). Qualitative and quantitative analyses were based on the percentage of empty stomachs, weight of stomach contents, mean mumber of prey items and quarterly distribution of each item (Hyslop, 1980). Seasonality in the diet was studied considering quarters A, B, C and D.

Table I. - List of food types found in stomachs of *Carcharhinus porosus* according to developmental stage, and codes used in feeding habit histograms presented in figure 8.

Prey items	Juveniles	Adults	Code
Molluscs			CEPH
Lolliguncula brevis	X	X	
Crustaceans			CRUS
Peneidae			
Xyphopenaeus kroyeri	X	X	
Portunidae			
Callinectes spp.	X	X	
Elasmobranchs			ELAS
Rhizoprionodon sp.		X	
Dasyatis sp.		X	
Teleosts			
Clupeidae			CLUP
Ophistonema oglinum	X		
Engraulidae			ENG
Anchoa spinifer	X	X	
Pterengraulis atherinoides	X		
Ariidae			ARI
Arius proops		X	
Bagre bagre	X		
Scianidae			SCI
Cynoscium steidachneri	X		
Macrodon ancylodon	X	X	
Stellifer naso	X	X	
Menthicirrhus americanus		X	
Ephippidae			EPI
Chaetodipterus faber		X	
Mugilidae			MUG
Mugil incilis	X		
Polynemidae			POLY
Polydactilus virginicus	X		
Stromateidae			STRO
Peprilus paru	X		
Trichiuridae			TRI
Trichiurus lepturus	X		
Soleidae			SOL
Achirus achirus	X		
Unidentified items			UN

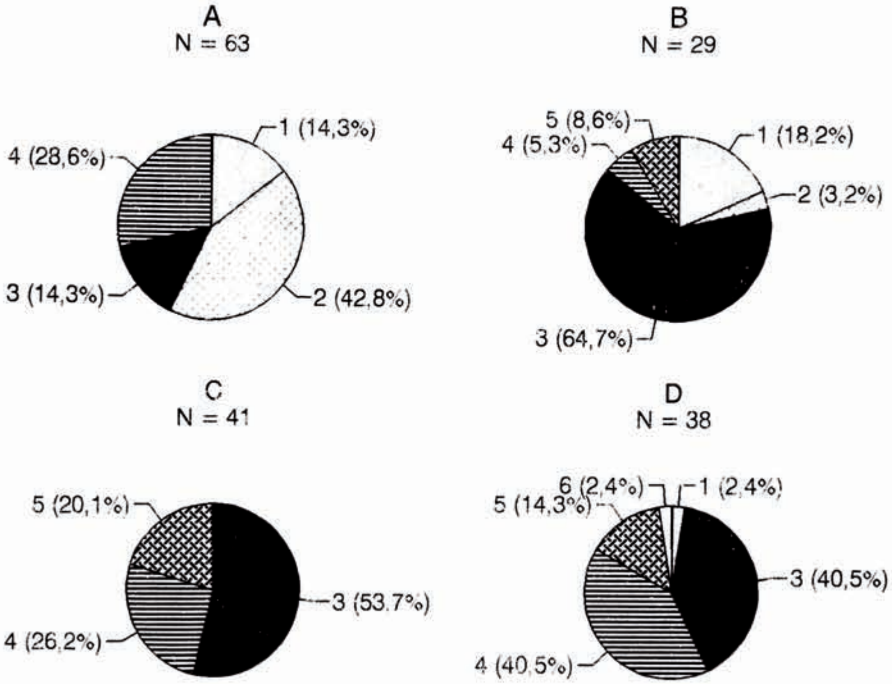

Fig. 3. - Quarterly relative diet composition of *Carcharhinus porosus* in Northern Brazil. A corresponds to June, July and August, B corresponds to September, October, November, C corresponds to December, January and February and D corresponds to March, April and May. Values given in parentheses are percentage by number. Main food categories are represented by numbers 1 to 6: Crustaceans = 1; *Stellifer naso* = 2; Unidentified bony fishes = 3; Other bony fishes (Stromateids, Engraulids, Sciaenids, Mugilids) = 4; *Macrodon ancylodon* = 5; Molluscs= 6. N is sample size.

Quarter A corresponded to June, July, August; quarter B to September, October, November, and so forth.

To examine size-related variations in diet, males and females larger than 70 cm TL were considered adults (Lessa, 1986-1987, 1988).

The Shannon diversity index (H') as presented by Hook (1991), was used to compare juvenile and adult groups. It was calculated by taking into account the number of individuals in each taxon or category listed in table I.

For statistical treatment Snedecor and Cochran (1980), Sokal and Rohlf (1981), and Siegel (1981) were followed. Statistical tests were performed using Minitab package.

RESULTS

Diet was evaluated by analyzing a sample made up of 94 males and 77 females of which 111 juveniles and 60 adults had food in their stomachs (25% of the complete sample). No significant differences were found when proportions were compared for males and females (z with Yate's correction = 1.22; $P = 0.222$) whilst, for juvenile vs. adult differences were considered significant (z with Yate's correction = 3.823; $P < 0.001$).

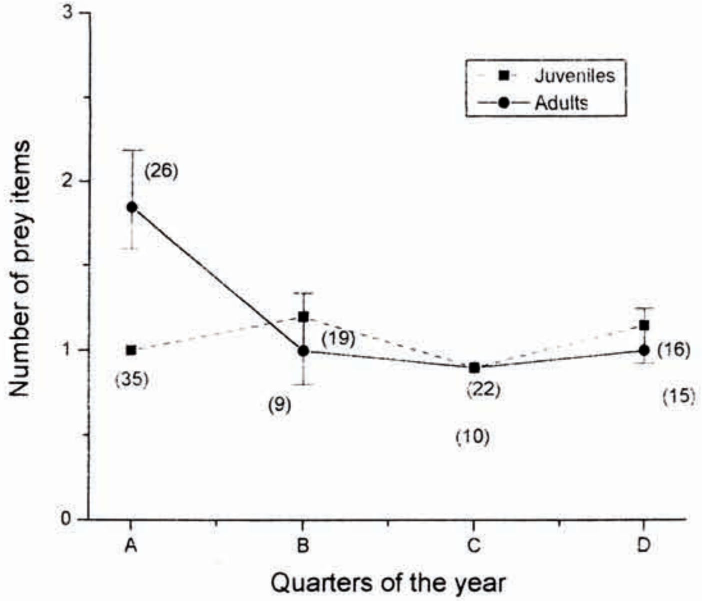

Fig. 4. - Quarterly mean mumber of prey items for juvenile and adult *Carcharhinus porosus* from Northern Brazil. A, B, C, D as in figure 3. Vertical bars represent ± S.D. Values given in parentheses correspond to the number of stomachs containing food.

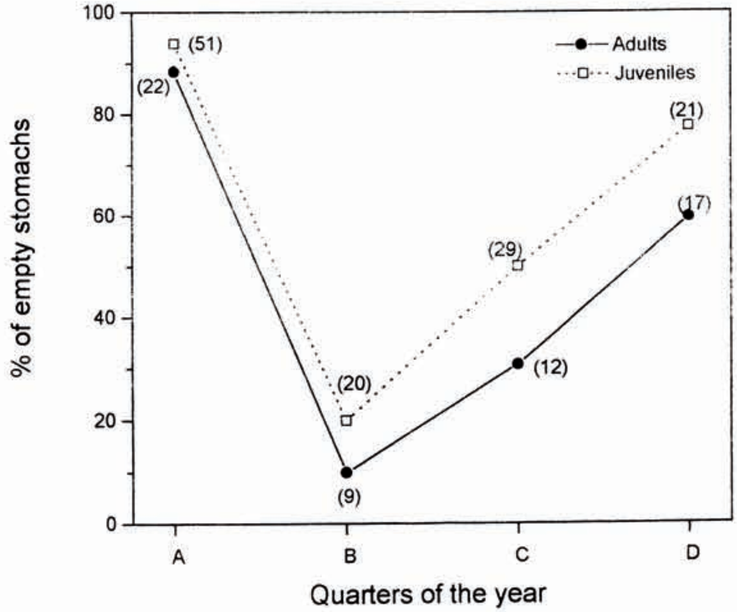

Fig. 5. - Quarterly percentage of empty stomachs for juvenile and adult *Carcharhinus porosus* from Northern Brazil. A, B, C, D as in figure 3. Values given in parentheses correspond to the number of stomachs with prey.

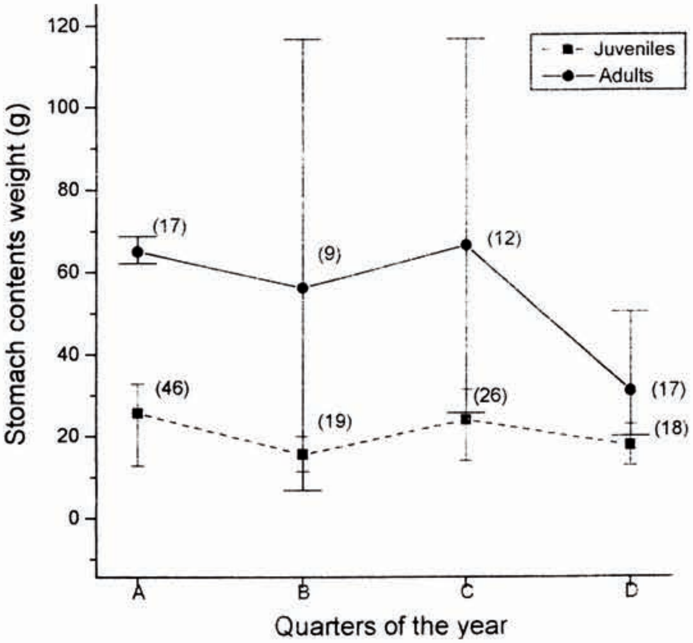

Fig. 6. - Quarterly mean weight of stomach contents in juvenile and adult *C. porosus* from Northern Brazil. A, B, C, D as in figure 3. Vertical lines represent ± S.D. Values given in parentheses correspond to the number of stomachs containing food.

Table I shows the items which make up the diet of both juveniles and adults. Juveniles displayed a wider spectrum of items than adults as attested by the Shannon diversity index (H' = 0.932 for juveniles vs. H' = 0.827 for adults). Such a result may have been influenced by the low number of adults (35%) in the sample.

Bony fishes represented more than 80% of numerical observations all year round (Fig. 3). *Macrodon ancylodon* and *Stellifer naso* were, among fish identified, the main prey present in stomachs from December to August. Several other species, belonging to the Sciaenidae, Mugilidae, Engraulidae and Stromateidae families together represented from 5.3% to 40.5% of the diet during the whole year. Unidentified bony fishes were also an important part of year-round contents.

Crabs (*Callinectes exasperatus*, *C. ornatus*, *Callinectes sp.*) and shrimps (*Xiphopenaeus sp.*) were present in samples from quarters D to B, but absent in quarter C.

Significant differences could not be found in the annual mean number of prey present in stomach contents of juveniles (Kruskal-Wallis, $H = 9.87$, $df = 2$, $p > 0.05$). In adults, the mean number of prey almost doubled that of juveniles in quarter A, a difference that was significant (Mann-Whitney *U*-test, $p < 0.05$) (Fig. 4).

The number of empty stomachs was significantly higher both in juveniles and adults in quarters A and D than in B or C. Using a variance test for homogeneity of the binomial distribution a $\chi^2 = 36.370$ ($df = 3$, $p < 0.05$) for juveniles and a $\chi^2 = 15.77$ ($df = 3$, $p < 0.05$) for adults were calculated. The Kolmogorov-Smirnov test did not show differences between juvenile and adult distributions (D-max = 0.0918; $\alpha = 0.1305$) (Fig. 5).

The mean weight of stomach contents in adults, calculated excluding empty stomachs was significantly different (Kruskal-Wallis, $H = 6.67$; $df = 3$; $p < 0.05$) over

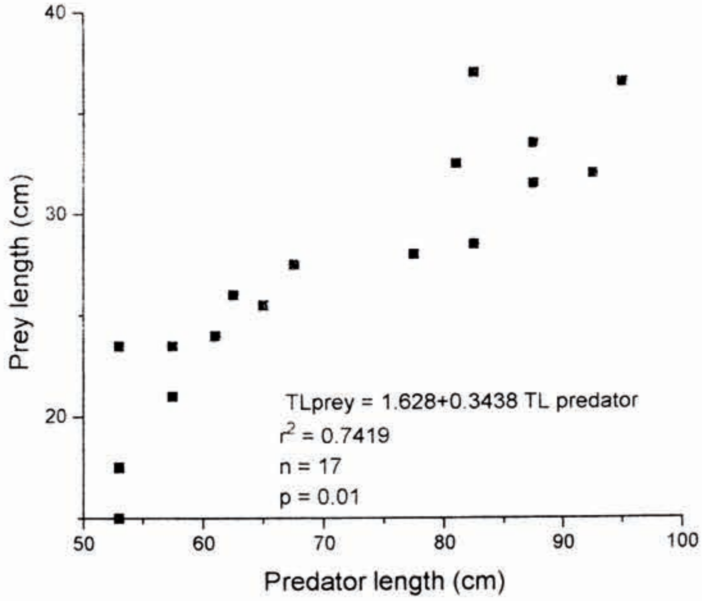

Fig. 7. - Relationship between total length of the prey species *Macrodon ancylodon* and its predator *Carcharhinus porosus*.

the year. It remained fairly constant in quarters A, B, and C and decreased significantly in quarter D when it reached < 40 g (Mann-Whitney *U*-test, $p < 0.05$) (Fig. 6). In quarters B and C, weights were remarkably variable, as shown by the magnitudes of standard deviation in figure 6. The weight of prey in juveniles remained quite constant, ranging from about 25 g in quarters A and C, to about 20 g in quarters B and D. In this case, the Kruskal-Wallis test did not reveal any significant difference over the year ($H = 8.65$, $df = 3$, $p > 0.05$).

The size of *Macrodon ancylodon*, estimated by means of a linear regression between otolith length and total length (Saul and Lessa, 1991), was related to predator size. The relationship was: $TL_{prey} = 1.628079 + 0.343785\ Tl_{predator}$ ($r^2 = 0.741915$, $n = 17$; $p = 0.01$) (Fig. 7).

Analysis of changes in diet according to size showed a higher number of prey categories in the stomach contents of juveniles, when compared to adults of both sexes (Fig. 8). Sciaenids were present in stomachs of most length classes in both sexes. Engraulids, soleids and trichiurids were more important in stomach contents of juveniles. Elasmobranchs were found only in stomachs of adult males.

DISCUSSION

Several fish species dominate the diet of *C. porosus*, attesting to the piscivorous feeding habits of this species. Fish prey species observed in the stomachs are quite common in the area where *C. porosus* specimens were collected, suggesting that these sharks are opportunistic predators that feed on the most abundant prey (Martins-Juras *et al.*, 1987; Saul and Lessa, 1991).

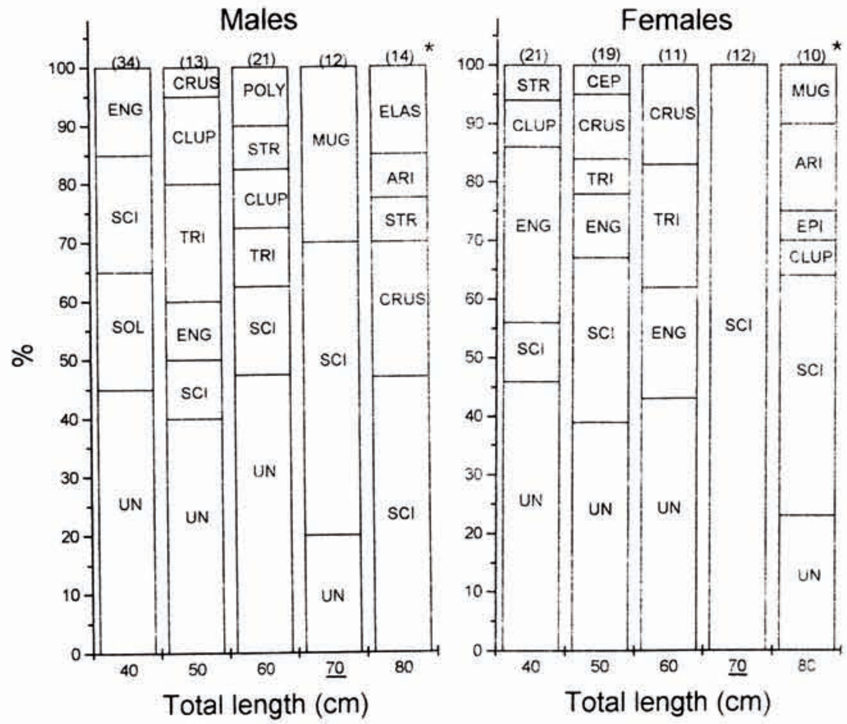

Fig. 8. - Relative proportions by number of major dietary components by length class for *Carcharhinus porosus* from northern Brazil. Codes for food items are listed in table I. Number of individuals examined by length class is given in parentheses at the top of each graph. Total length corresponds to the midpoint of the class interval. Underlined length in each graph corresponds to size at maturity. Asterisk indicates that all individuals larger than 85 cm are included.

Carcharhinus plumbeus, Negaprion brevirostris, Galeorhinus galeus, Raja radiata and other species of elasmobranchs are also believed to be opportunistic feeders, preying on the most abundant prey (Wetherbee *et al.*, 1990; Pedersen, 1995). According to Wetherbee *et al.* (1990), the opportunistic feeding nature of sharks is suggested by changes in diet with size, season, and habitat. Ontogenetic shifts in diet were reported by these authors for several species and are considered a common pattern among sharks. In many species, juveniles remain in protected nursery areas, where food availability may be relatively low, whereas mature individuals move away from these sites and diversity and availability probably increases. Thus, dietary shifts are frequently related to different spatial distributions among age or size groups (Stoner and Livingstone, 1984; Wetherbee *et al.*, 1990; Pedersen, 1995).

Stoner and Livingstone (1984) refer to a higher predation efficiency with increasing age. In our study it was observed that only adult males of *C. porosus* preyed on elasmobranchs. Similarly, Cortés and Gruber (1990) found elasmobranchs only in the diet of the larger size classes of *N. brevirostris*.

The largest specimens of *C. porosus* eat the largest prey, but not the highest number of prey items (Figs 4, 6). This lends support to the notion of size selectivity. The relationship between predator and prey size for *M. ancylodon* further confirms that, at least in that species, size selectivity does occur. Identical observations were made by Ware (1972), Ross (1977) and Cortés *et al.* (1996), who found larger prey to occur in the diet of larger specimens.

As in our study, Cortés and Gruber (1990) found only one or two prey items in the majority of stomachs of *N. brevirostris* examined (78%). We can thus infer that, like the lemon shark, *C. porosus* feeds intermittently rather than continously, in which case we would expect to find several items in stomachs demonstrating different degrees of digestion.

The percentage of empty stomachs found in *C. porosus* in the overall sample (75%) is one of the highest reported for sharks caught using nets or other non-baited methods of capture (Wetherbee *et al.*, 1990). According to these authors, a high incidence of empty stomachs may be the result of a feeding schedule characterized by short bouts, followed by longer periods of digestion, with little or no feeding in the interim.

We have shown that *C. porosus* is mainly a piscivorous predator that probably feeds intermittently, as attested by the high incidence of empty stomachs, in an opportunistic manner. Dietary diversity appears to decrease with size and we have demonstrated a seasonal dietary shift and size selectivity with at least one prey type.

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REFERENCES

ANONYMOUS, 1976. - Pesquisa dos recursos pesqueiros da plataforma continental maranhense. *Série Estudos de Pesca*: 6, 67 p.Superintendência do Desenvolvimento do Nordeste - SUDENE, DRN, Recife.

ANONYMOUS, 1983. - Avaliação do potencial de tubarões da costa nordeste do Brasil. *Série Estudos de Pesca*, 10, 31 p. Superintendência do Desenvolvimento do Nordeste - SUDENE, DRN, Recife.

COMPAGNO L.V.J., 1984. - FAO Species Catalogue. Sharks of the World. An annotated and illustrated Catalogue of Shark Species known to Date. Part 2. Carcharhiniformes. FAO Fish. Synop. 125, Vol 4. Pt.2: 251-655.

CORTÉS E. & S. GRUBER, 1990. - Diet, feeding habits and estimates of daily ration of young lemon sharks *Negaprion brevirostris* (Poey). *Copeia*, 1990: 204-218.

CORTÉS E., MANIRE C.A. & R.E. HEUTER, 1996. - Diet, feeding habits, and diel feeding chronology of the bonnethead shark, *Sphyrna tiburo*, in southwest Florida. *Bull. Mar. Sci.*, 58(2): 353-367.

FIGUEIREDO J.L., 1977. - Manual de Peixes Marinhos do Sudeste do Brasil. I. Introdução. Cação, Raias e Quimeras. 104 p. Mus. Zool. São Paulo, Univ. São Paulo.

FIGUEIREDO J.L. & N.A. MENEZES, 1978. - Manual de Peixes Marinhos do Sudeste do Brasil; II. Teleostei (1). 110 p. Mus. Zool. São Paulo, Univ. São Paulo.

FIGUEIREDO J.L. & N.A. MENEZES, 1980. - Manual de Peixes Marinhos do Sudeste do Brasil. III. Teleostei (2). 90 p. Mus. Zool. São Paulo, Univ. São Paulo.

HOLDEN M.J., 1974. - Problems in the rational exploitation of Elasmobranchs populations and some suggested solutions, pp. 117-138. *In:* Sea Fisheries Research (Harden Jones F.R., ed.). Logos Press London.

HOOK J.H., 1991. - Seasonal variation in relative abundance and species diversity of fishes in the South Bay. *Contr. Mar. Sci. Univ. Texas*, 32: 127-141.

HYSLOP E.J., 1980. - Stomach contents analysis - a review of methods and their application. *J. Fish. Biol.*, 17: 411-429.

LESSA R.P., 1986-1987. - Contribuição ao conhecimento da Biologia de *Carcharhinus porosus* Ranzani, 1839 (Pisces, Chondrichthyes) das Reentrâncias Maranhenses. *Acta Amazônica*, 16-17: 73-86.

LESSA R.P., 1986. - Levantamento ictiofaunístico dos elasmobrânquios (Pisces, chondrichthyes) do litoral ocidental do estado do Maranhão, Brasil. *Bol. Lab. Hidrobiol., São Luis*, 7: 21-41.

LESSA R.P., 1988. - Biometria de tubarões costeiros aplicada ao controle de desembarques no norte do Brasil - Maranhão. *Ciênc. Cult.*, 40(9): 892-897.

MARTINS-JURAS I.A.G., JURAS A.A. & N.A. MENEZES, 1987. - Relação preliminar dos Peixes da Ilha de São Luis, Maranhão, Brasil. *Rev. Bras. Zool., São Paulo*, 4(2): 105-113.

PEDERSEN S.A., 1995. - Feeding habits of starry ray (*Raja radiata*) in West Greenland waters. *ICES, J. Mar. Sci.*, 52: 43-43.

ROSS S.T., 1977. - Patterns of resource partitioning in sea robins (Pisces: Triglidae). *Copeia*, 1977: 561-571.

SADOWSKY V., 1967. - Selachier aus dem Litoral von São Paulo, Brasilien. *Bietr. Neotrop. Fauna*, 5: 71-88.

SAUL A. & R. LESSA, 1991. - Contribuição ao conhecimento da alimentação de elasmobrânquios da Costa Norte do Brasil por meio do estudo de otólitos. *Rev. Brasil. Biol., Rio de Janeiro*, 51(3): 521-535.

SIEGEL S., 1981. - Estatística não Paramétrica para Ciências do Comportamento. 350 p. McGraw-Hill do Brasil LTDA Ed., São Paulo.

SNEDECOR G.W. & W.G. COCHRAN, 1980. - Statistical Methods. 6th. edit. Iowa State Univ. Press, Ames.

SOKAL R.R. & J.F. ROHLF, 1981. - Biometry. 859 p. W.H. Freeman and Co., New York.

STONER A.W. & R.J. LIVINGSTON, 1984. - Ontogenetic patterns in diet and feeding morphology in sympatric sparid fishes from seagrass meadows. *Copeia*, 1984: 174- 187.

WARE D.M., 1972. - Predation by rainbow trout (*Salmo gairdneri*): the influence of hunger, prey density and prey size. *J. Fish. Res. Bd. Can.*, 29: 1193-1201.

WERTHERBEE B.M., GRUBER S.H. & E. CORTÉS, 1990. - Diet, feeding habits, digestion and consumption in sharks, with special reference to the lemon shark, *Negaprion brevirostris*. *NOAA Tech. Rep. NMFS*, 90: 29-47.

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